Design and Development of Sequential Rotary Valve

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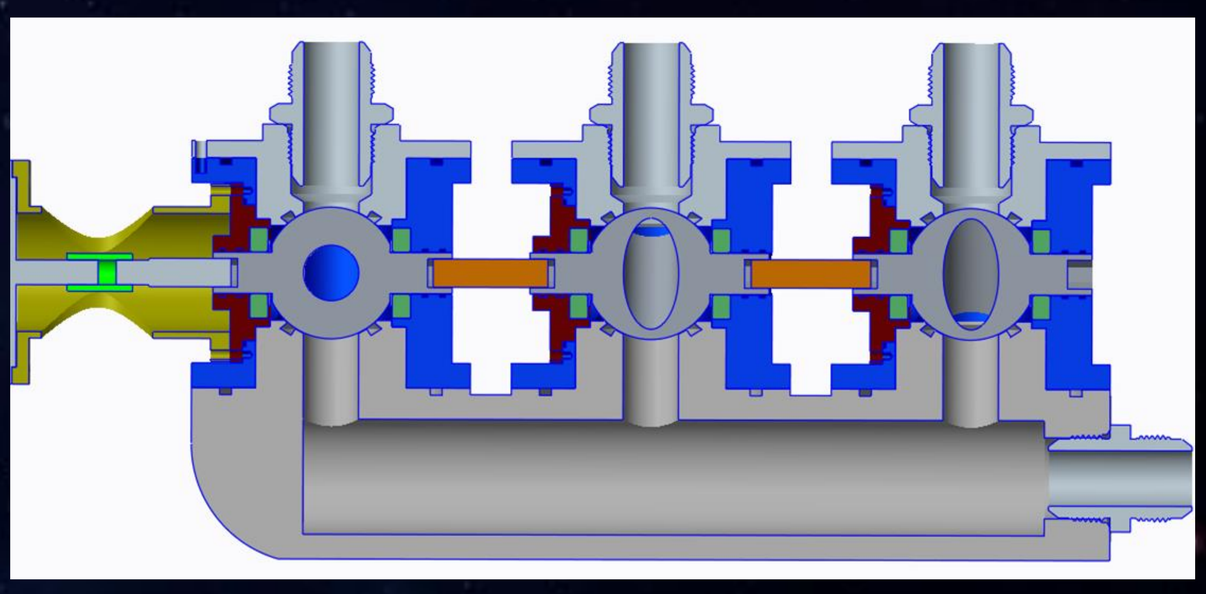
Overview

Valves are used to regulate the flow of fluids through systems. This rotary valve's main purpose is to fill, pressurize, empty, and vent three smaller tanks with the supply of one larger tank. Many different designs are being taken into consideration, which are each at different stages of development. The furthest along uses three ball valves on a common shaft to open and close their respective ports as the shaft completes one full rotation or cycle. We were tasked with advancing this design to its first test as a plastic model for flow verification, as well as sizing and ordering the necessary O-rings and fasteners. A motor will also be sized to satisfy the torque requirements, and will then be programmed using a Raspberry Pi to rotate the shaft at the calculated speed and dwelling times needed to fill each tank equally. In addition, we have also been advancing designs that use a camshaft and poppets. These are earlier on in their development, currently being sized to replicate the expected flow patterns of the rotary ball valve. Expected outcomes of this valve include bi-directionality, successful sealing under pressure, and accurate cycling.

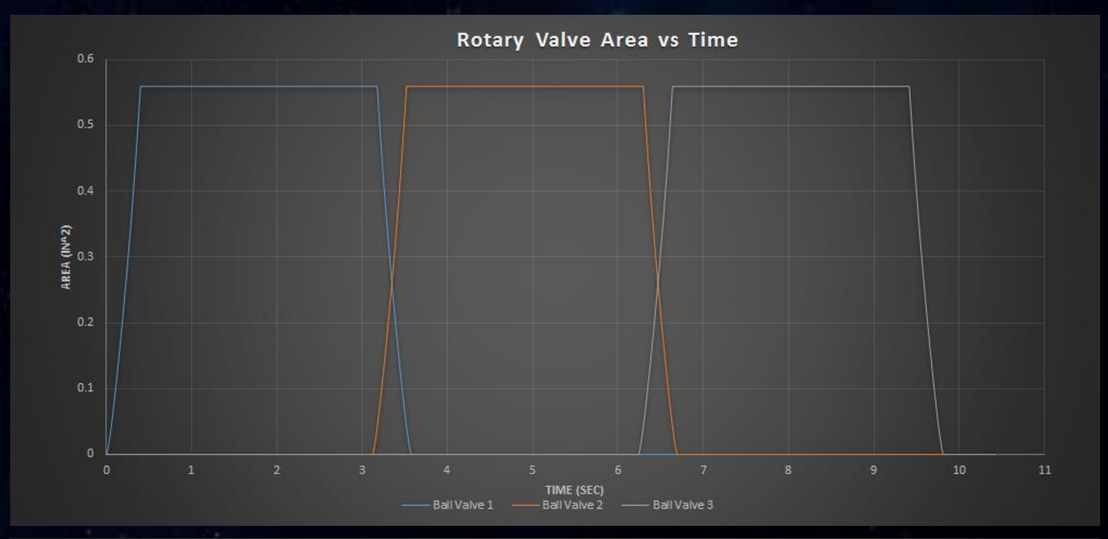
Testing/Completion of Design

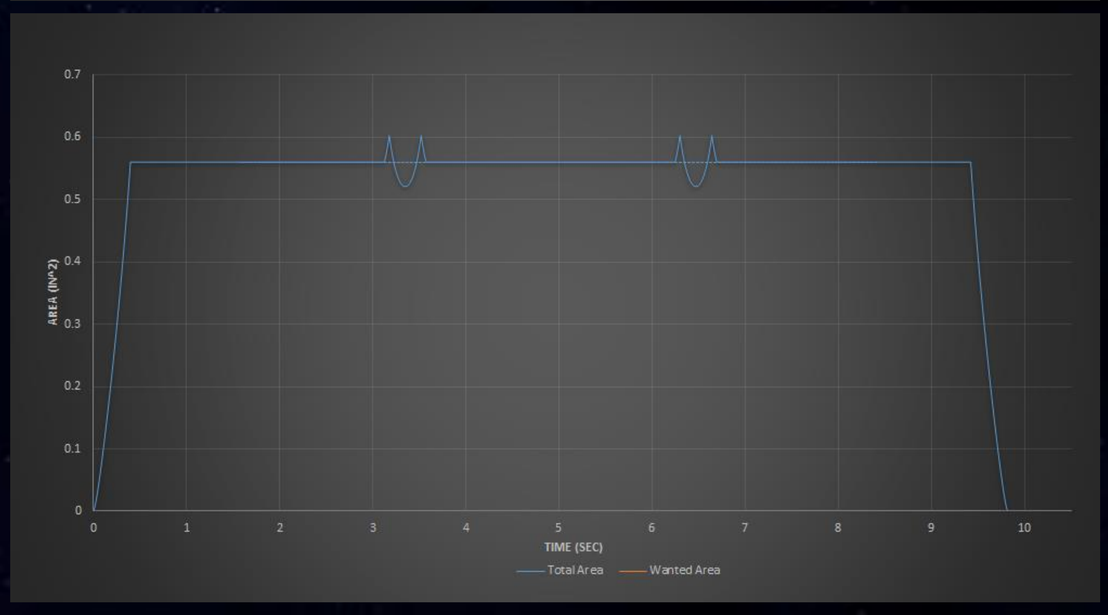
The first step of this project was to advance a design to be tested. The seals for the ball valves needed to be improved. Many concepts were considered and created in CREO until a dovetail was selected as the final design. The gland it provided allowed an O-ring to squeeze in the desired direction without allowing the bore in the ball to constantly scrape it, which would have destroyed it over time. Once the main seals were chosen, sizing of the other O-rings was completed. Finally, a motor mount was designed to transfer the motor power to the central shaft. A cross sectional photo of the valve can be seen below. A plastic model of this valve (excluding O-rings and fasteners) is currently being made for initial testing.



Movement Operation

The timing for each ball to open and close was previously calculated to ensure a near even fluid flow. The following graphs show the areas each ball's port will fill and the total area covered in one full cycle. A motor will be programmed using a Raspberry Pi to rotate the shaft with respect to the timing calculations by modifying the pulse width modulation and satisfying the determined dwelling times.





Future Work

After advancing the initial design to its first test, other designs have since been progressed. These newer designs use a cam/camshaft concept to sequentially lift and lower three poppets.

Additional Projects

TS116: Performed thermal tests to quantify the thermal expansion of a valve due to a hydrogen fire

4BCO2 Removal System: Worked on seals and rotating parts for a valve to be tolerant to FOD to prevent damaging to the carbon dioxide removal assembly on the ISS

Magnetic Valve: Tested a magnetically damped check valve to understand its flow and damping capabilities

Vacuum Chamber: Debugged the controls system of a vacuum chamber that stabilizes pressure

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